

What is claimed is:

1. A method for fabricating a nanoporous structure, said method comprising the steps of:
 - depositing an array of porogens on a substrate;
 - crystallizing the porogens such that the porogens are densely packed;
 - depositing a material from a vapor phase to fill open spaces between the porogens to form a structure with embedded porogens; and
 - inducing decomposition of the porogens.
2. The method of claim 1, wherein the steps of depositing an array of porogens, crystallizing, and depositing a material are repeated.
3. The method of claim 1, wherein the steps of depositing an array of porogens, crystallizing, and depositing a material are completed simultaneously.
4. The method of claim 1, wherein the steps of depositing an array of porogens and depositing a material are completed simultaneously.
5. The method of claim 1, wherein the step of depositing an array of porogens is performed by spray deposition.
6. The method of claim 5, wherein the step of depositing an array of porogens is performed using an ultrasonic atomizer.
7. The method of claim 1, wherein the step of depositing an array of porogens is performed using a syringe.

8. The method of claim 1, wherein the step of depositing an array of porogens further comprises applying an aqueous suspension of porogens over a surface of the substrate.
9. The method of claim 8, wherein the method further comprises utilizing spin coating to disperse the aqueous suspension over the substrate.
10. The method of claim 1, wherein the step of crystallizing the porogens further comprises thermal gradient heating of the substrate.
11. The method of claim 1, wherein the method further comprises heating the substrate to approximately 95 °C prior to the step of depositing the array of porogens.
12. The method of claim 1, wherein the substrate is selected from the group consisting of silicones, silicon dioxides, silicon-germaniums, glasses, silicon nitrides, ceramics, aluminums, coppers, and gallium arsenides.
13. The method of claim 1, wherein the step of depositing an array of porogens comprises depositing an ordered array of porogens.
14. The method of claim 1, wherein the step of depositing an array of porogens comprises depositing a random array of porogens.
15. The method of claim 1, wherein the step of depositing an array of porogens comprises depositing porogens that are uniform in size.
16. The method of claim 1, wherein the step of depositing an array of porogens comprises depositing porogens that vary in size.
17. The method of claim 1, wherein the step of depositing an array of porogens comprises depositing porogens that have a mean diameter less than 100 nm.

18. The method of claim 1, wherein the step of depositing an array of porogens comprises depositing porogens that are selected from the group consisting of spherical, circular, planar, linear, cone-shaped, triangular, rectangular, pentagonal, hexagonal, octagonal, and irregular shaped.
19. The method of claim 1, wherein the step of depositing a material further comprises utilizing chemical vapor deposition (CVD).
20. The method of claim 1, wherein the step of depositing a material further comprises utilizing pulsed plasma chemical vapor deposition (CVD).
21. The method of claim 1, wherein the steps of depositing an array of porogens and depositing a material from a vapor phase are performed at specified flow rates, such that porosity of the nanoporous structure can be varied.
22. The method of claim 1, wherein the step of depositing a material further comprises filling the open spaces with an aqueous solution.
23. The method of claim 1, wherein the step of depositing a material further comprises filling the open spaces with a precursor reagent.
24. The method of claim 23, wherein the precursor reagent is selected from the group consisting of halides, hydrides, metal organic compounds, metal alkyls, metal dialylamides, metal diketonates, metal carbonyls, and complexes or ligands thereof.
25. The method of claim 1, wherein the step of depositing a material further comprises generating a species with a low sticking coefficient.
26. The method of claim 1, wherein the step of depositing a material further comprises generating a neutral species.

27. The method of claim 1, wherein the step of depositing a material further comprises using low energy plasma energy excitation.
28. The method of claim 1, wherein the step of depositing a material further comprises filling the open spaces with a silicate material.
29. The method of claim 1, wherein the silicate material is selected from the group consisting of silane, acyclic and cyclic siloxanes, acyclic and cyclic silanes, cyclic organosiloxanes, alkyl, alkenyl, or alkoxy substituted silanes, alkyl and alkoxy silanes, alkylated (methylated) derivatives of silane, methylsilane, dimethylsilane, trimethylsilane and tetramethylsilane, $\text{Si}_2(\text{CH}_3)_n\text{H}_{6-n}$ ($n=1-6$), C_6F_n ($n=6-12$), $\text{C}_n\text{F}_{2n+2}$ ($n>1$), $\text{CH}_n\text{F}_{4-n}$ ($n=1-4$), $\text{Si}_x\text{F}_{2x+2}$ ($x=1-4$), $\text{SiH}_n\text{F}_{4-n}$ ($n=1-4$), $\text{Si}_n\text{H}_{2n+2}$ ($n=1-3$), $\text{Si}(\text{OC}_n\text{H}_{2n+1})_4$ ($n=1-2$), SiH_2Cl_2 , TEOS, and $\text{Si}(\text{OC}_2\text{H}_5)_4$, and derivatives thereof.
30. The method of claim 1, wherein the step of depositing a material further comprises filling the open spaces with a metal material.
31. The method of claim 1, wherein the step of depositing a material further comprises filling the open spaces with a ceramic material.
32. The method of claim 1, wherein the method further comprising selecting porogens that are formed from materials selected from the group consisting of polystyrene, silica, styrene, halogenated styrene, hydroxy-substituted styrene, lower alkyl-substituted styrene, acrylic acid, acrylamide, methacrylic acid, methyl acrylate, ethyl acrylate, butyl acrylate, polyacrylate, ethylene oxide, propylene oxide, poly(methyl methacrylate) (PMMA), poly(alpha-methyl styrene), aliphatic polycarbonates, poly(propylene carbonate) and poly(ethylene carbonate), polyesters, polysulfones, polylactides, polylactones, and combinations thereof.

33. The method of claim 1, wherein the step of inducing decomposition of the porogens further comprises pyrolysis.
34. The method of claim 1, wherein the step of inducing decomposition of the porogens further comprises irradiation.
35. The method of claim 1, wherein the step of inducing decomposition of the porogens further comprising curing the material.
36. The method of claim 1, wherein the method further comprises establishing a rate of decomposition of the porogens.
37. The method of claim 36, wherein the step of establishing the rate of decomposition further comprises varying temperature and time of the decomposition step.
38. The method of claim 1, wherein the method further comprises selecting a porogen with a decomposition temperature above that needed to cure the material.
39. The method of claim 1, wherein the method further comprises producing an anti-reflective coating on the substrate.
40. The method of claim 1, wherein the nanoporous structure has a dielectric constant less than 2.7.
41. The method of claim 1, wherein the nanoporous structure has a dielectric constant less than 2.0.
42. The method of claim 1, wherein the material is selected from the group consisting of metals, ceramics, OSGs, aluminum oxides, silicon dioxides, cerium oxides, calcium hydroxyapatites, silicons, silicon carbides, and gallium arsenides.

43. The method of claim 1, wherein the nanoporous structure has a porosity between 1% to 99%.
44. The method of claim 1, wherein the nanoporous structure has a porosity greater than 50%.
45. The method of claim 1, wherein the nanoporous structure has a porosity greater than 70% porosity.
46. The method of claim 1, wherein the step of inducing decomposition of the porogens is performed under ambient conditions at elevated temperatures between 280 °C and 500 °C.
47. A porous low dielectric material comprising a matrix including an OSG framework and having therein a plurality of nanopores dispersed throughout the framework, wherein the nanopores are induced by porogen decomposition.
48. The porous low dielectric material of claim 47, wherein the material has a dielectric constant less than 2.7.
49. The porous low dielectric material of claim 47, wherein the material has a dielectric constant less than 2.0.
50. The porous low dielectric material of claim 47, wherein the material further comprises a refractive index less than 1.2, such that the material can be used as an anti-reflective coating.
51. The porous low dielectric material of claim 47, wherein the material has a porosity greater than 50%.

52. The porous low dielectric material of claim 47, wherein the material has a porosity greater than 70%.
53. A porous metal material comprising a matrix including a metal framework and having therein a plurality of nanopores dispersed throughout the framework, wherein the nanopores are induced by porogen decomposition.
54. A porous ceramic material comprising a matrix including a ceramic framework and having therein a plurality of nanopores dispersed throughout the framework, wherein the nanopores are induced by porogen decomposition.
55. A porous catalysis comprising a matrix including a framework and having therein a plurality of nanopores dispersed throughout the framework, wherein the nanopores are induced by porogen decomposition.
56. A porous scaffold comprising a matrix including a framework and having therein a plurality of nanopores dispersed throughout the framework, wherein the nanopores are induced by porogen decomposition.
57. An electronic structure having multiple conductor layers comprising at least one ultra-low dielectric insulator with a network of porogen-induced nanopores in electrical communication with at least one of the conductor layers.
58. An apparatus for producing porous low dielectric material comprising:
a process chamber;
a substrate holder within the chamber;
a porogen depositing element deposited within the chamber and configured for depositing a quantity of porogens onto a substrate; and
a dielectric material depositing element configured for depositing a quantity of dielectric material onto a porogen-laden substrate such that the dielectric material covers the porogens and fills gaps between the porogens to form a matrix of

dielectric material, such that upon decomposition of the porogens a porous low dielectric material is obtained.

59. The device of claim 58, wherein porogen depositing element is a spraying element.

60. The device of claim 59, wherein the spraying element is an ultrasonic atomizer.

61. The device of claim 58, wherein the dielectric material depositing element is a CVD apparatus.

62. The device of claim 61, wherein the CVD apparatus is a plasma enhanced CVD apparatus.